

Seasonal Variations of the James Webb Space Telescope Orbital Dynamics

AAS 15-802

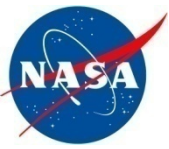
Jonathan Brown (a.i. solutions)

Jeremy Petersen (a.i. solutions)

Benjamin Villac (a.i. solutions)

Wayne Yu (NASA GSFC)

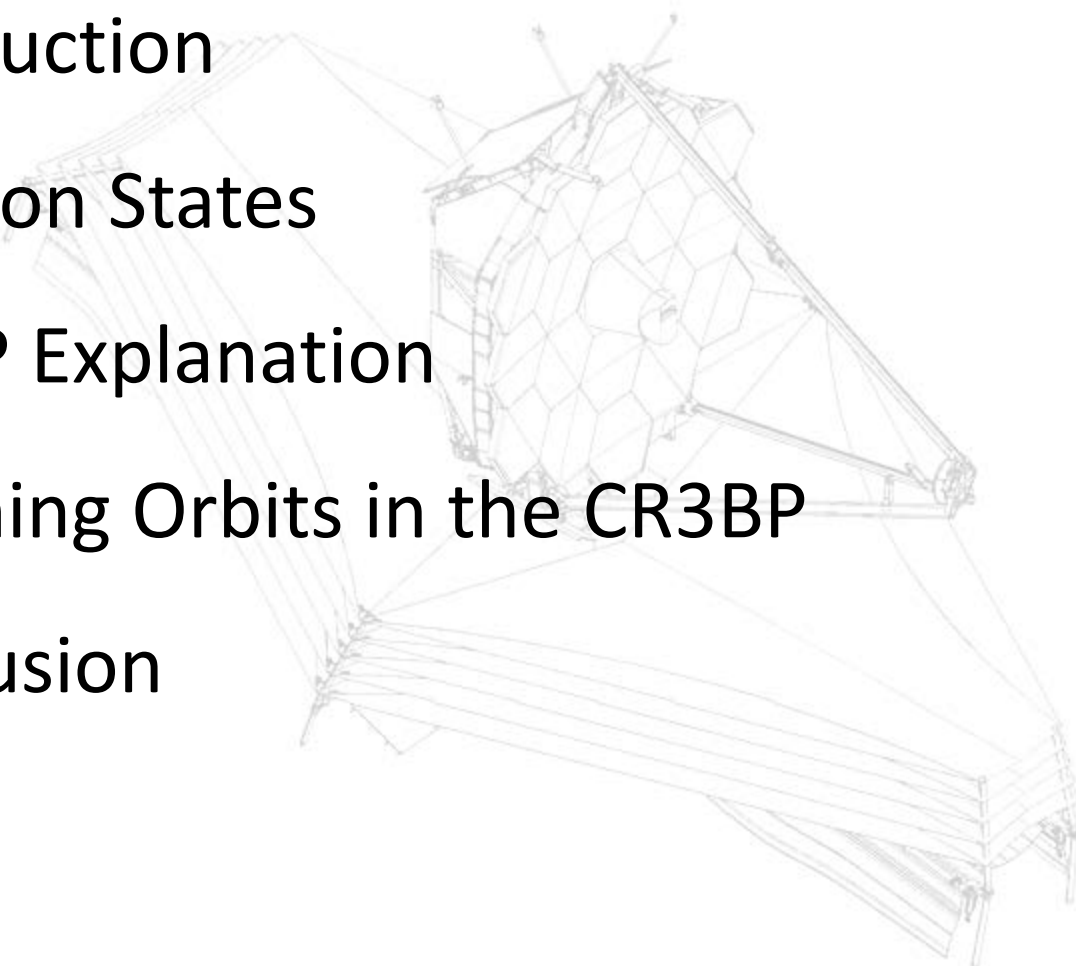




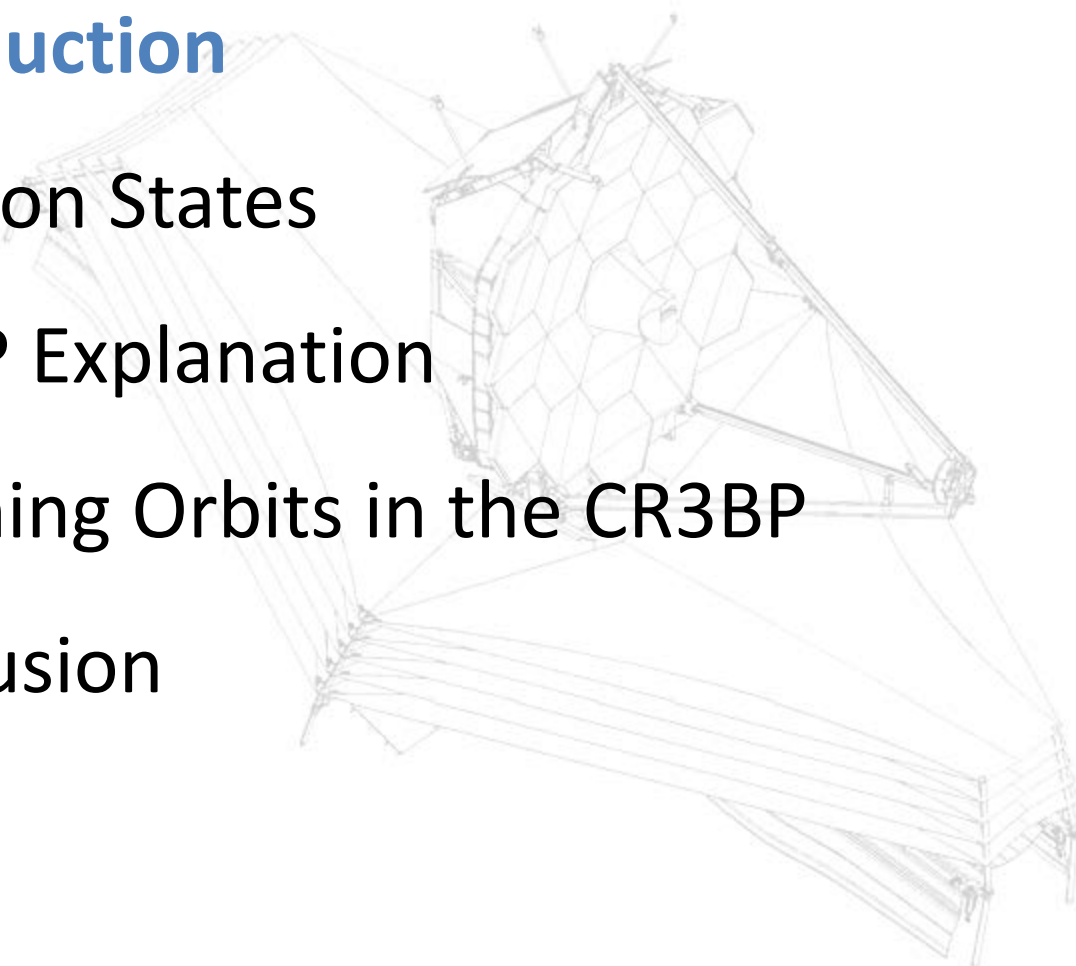
Agenda



- Introduction
- Injection States
- CR3BP Explanation
- Matching Orbits in the CR3BP
- Conclusion



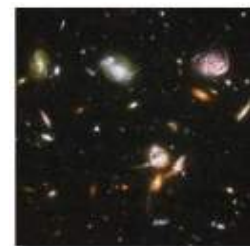
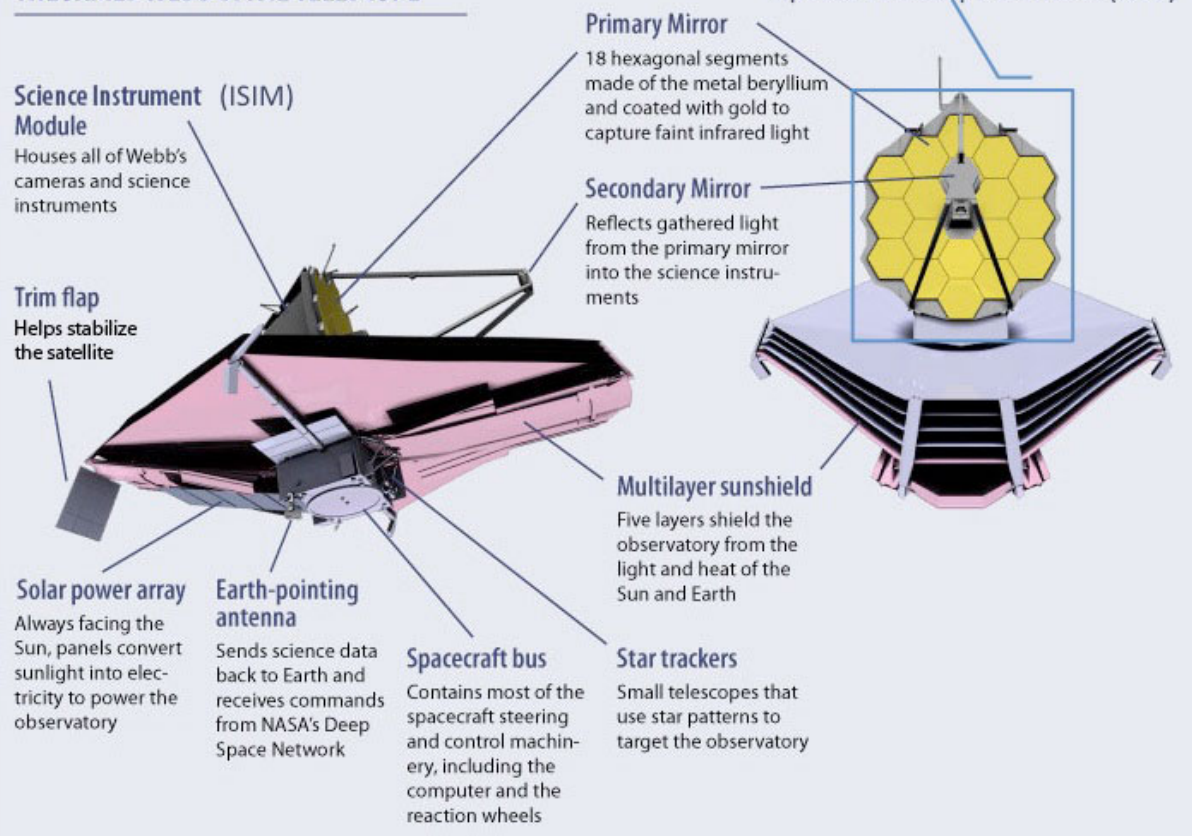
- **Introduction**
- Injection States
- CR3BP Explanation
- Matching Orbits in the CR3BP
- Conclusion



Introduction

JWST Science Themes

THE JAMES WEBB SPACE TELESCOPE



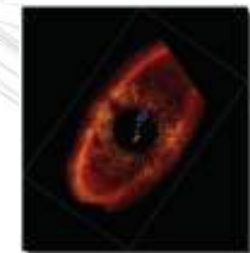
End of the dark ages: First light and reionization



The assembly of galaxies



Birth of stars and proto-planetary systems



Planetary systems and the origin of life

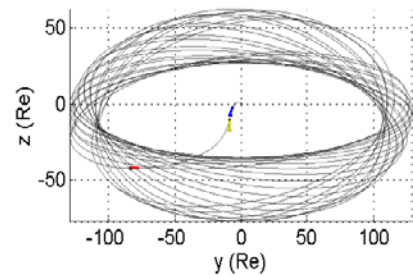
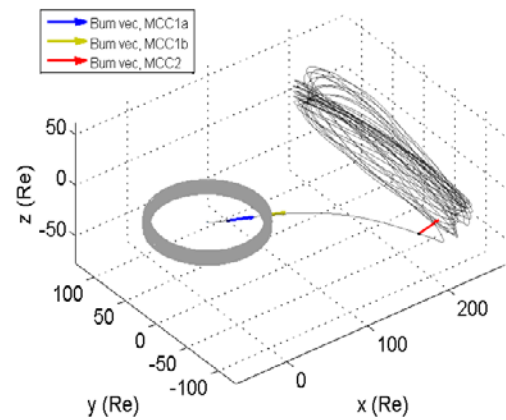
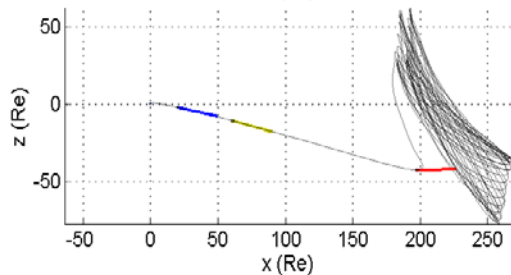
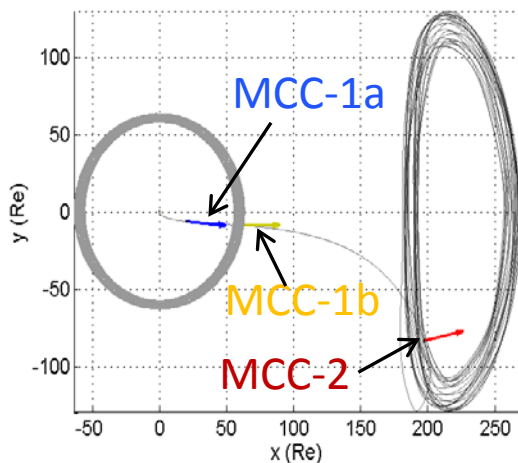
Image credit: <http://jwst.nasa.gov/observatory.html>



Representative JWST Orbit

Event	Time After LV Sep.
MCC-1a	12 hours
MCC-1b	2.5 days
Sunshield Deployment	5.5 days
MCC-2	30 days

Maneuver	ΔV Budget (m/s)
MCC-1a	41
MCC-1a Late	8
MCC-1b	7.5
MCC-2	5
Margin	5
Total	66.5



Operational Orbit Constraints
RLP Y: $\pm 832,000$ km (130 Re)
RLP Z: $\pm 532,000$ km (83 Re)





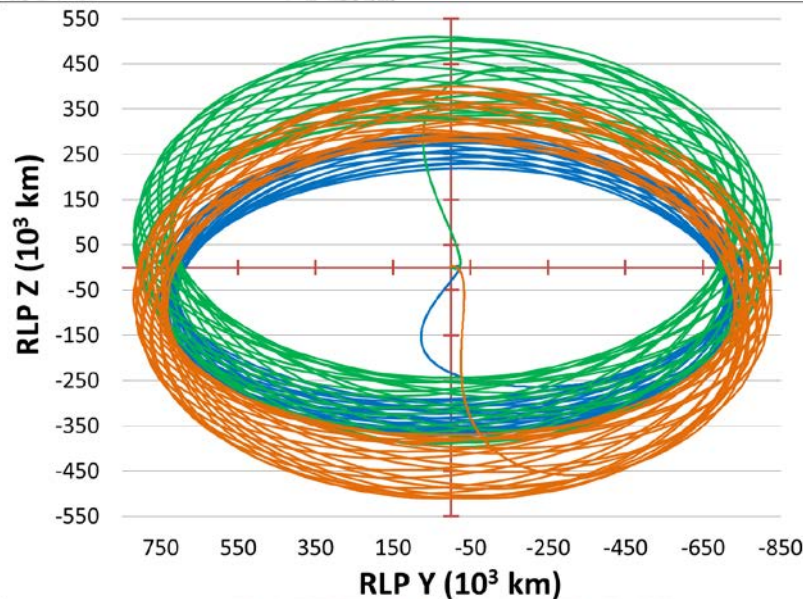
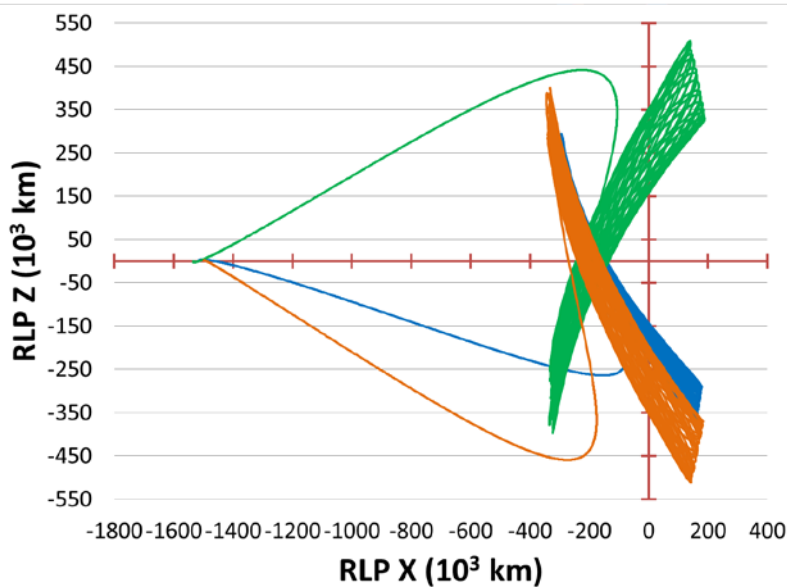
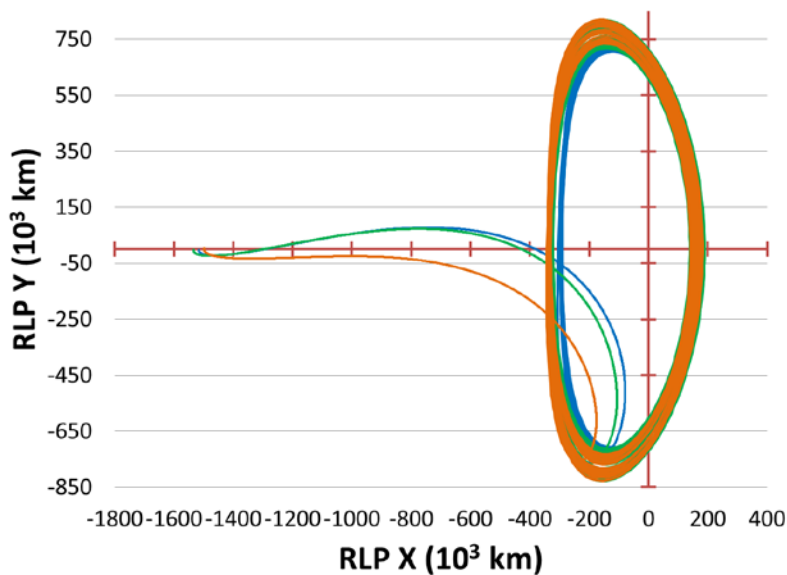
Representative JWST Orbits

Vastly different orbits
depending on launch time

01 Oct 2018 13:10 UTC

25 Nov 2018 12:45 UTC

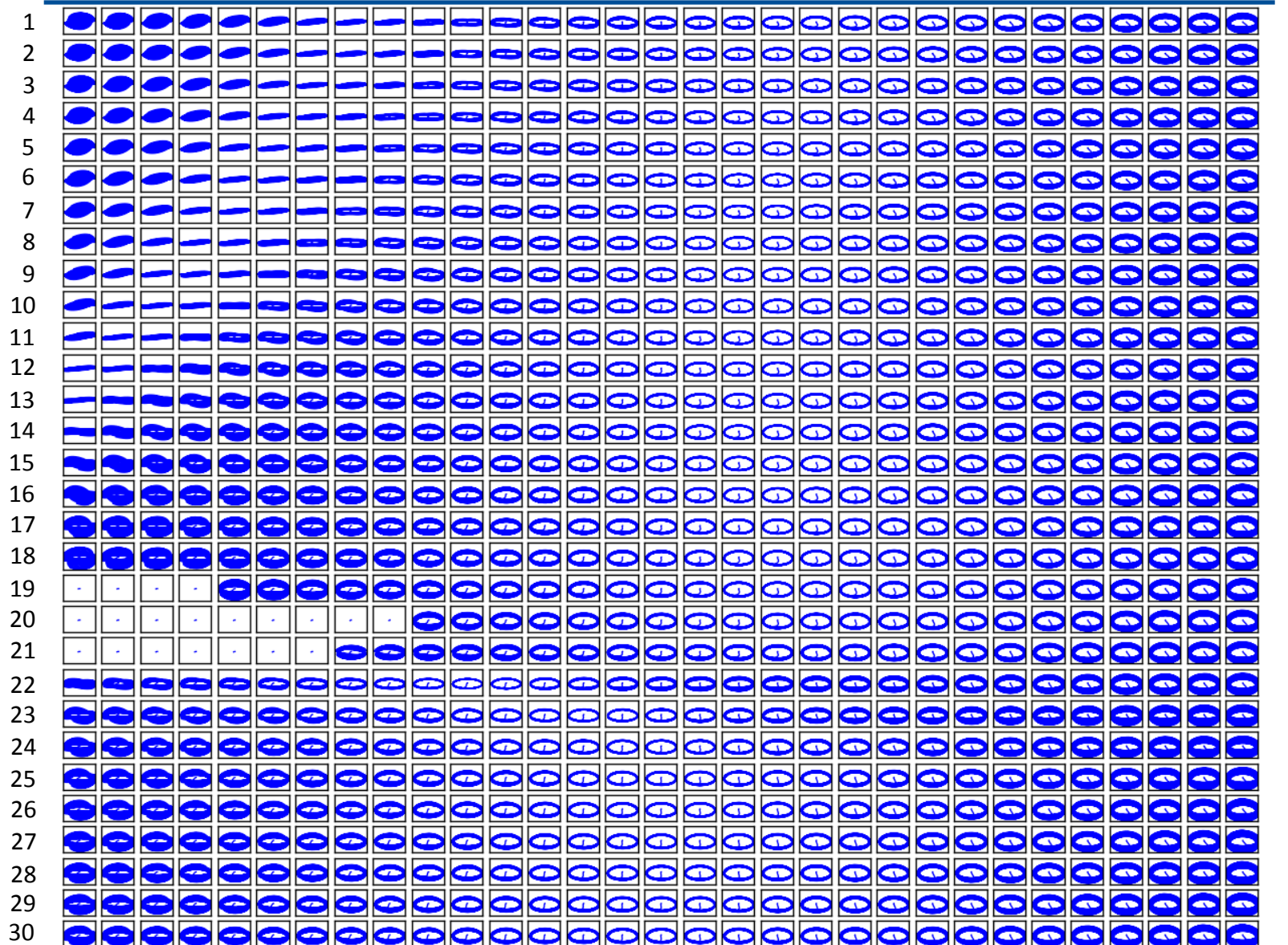
27 May 2019 13:15 UTC





Variation in Orbit Geometry

October 2018



11:30

12:00

12:30

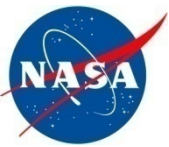
13:00

13:30

14:00

Launch Epoch (UTC)

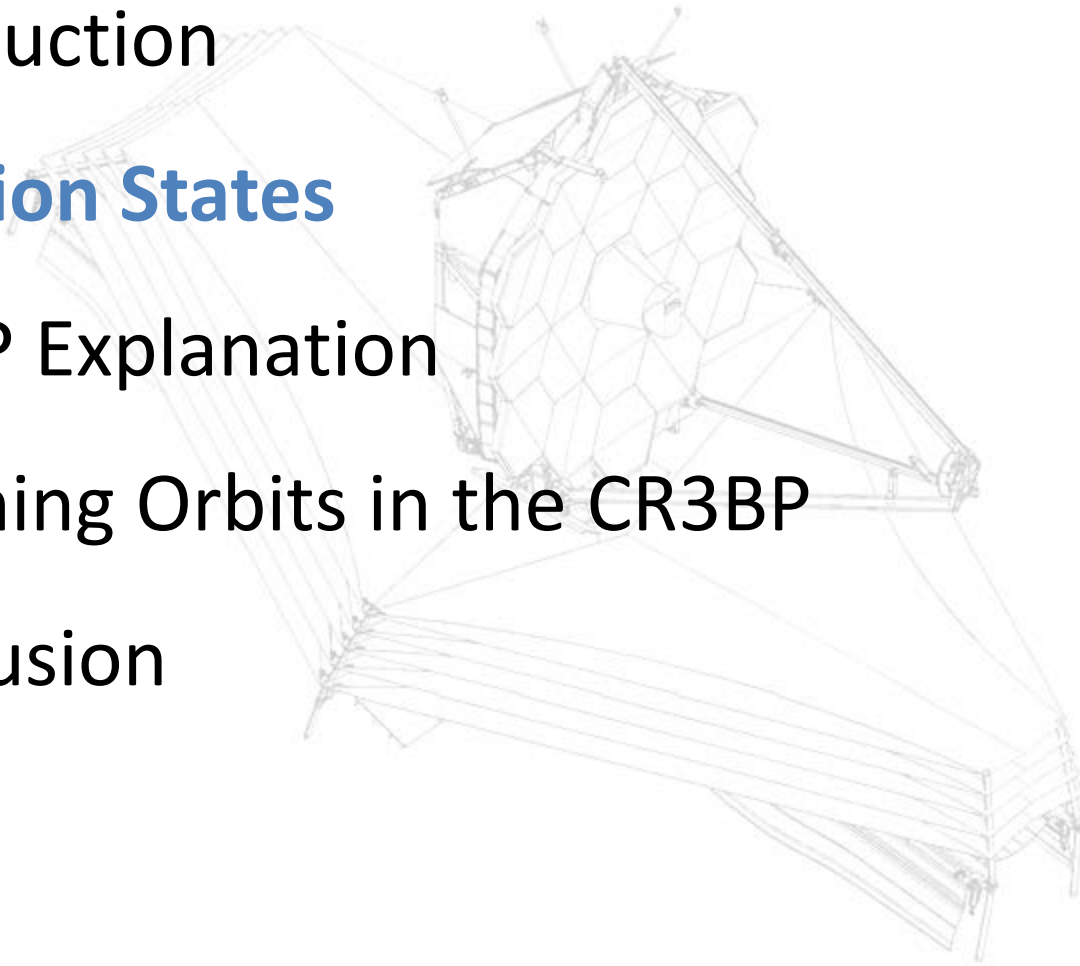




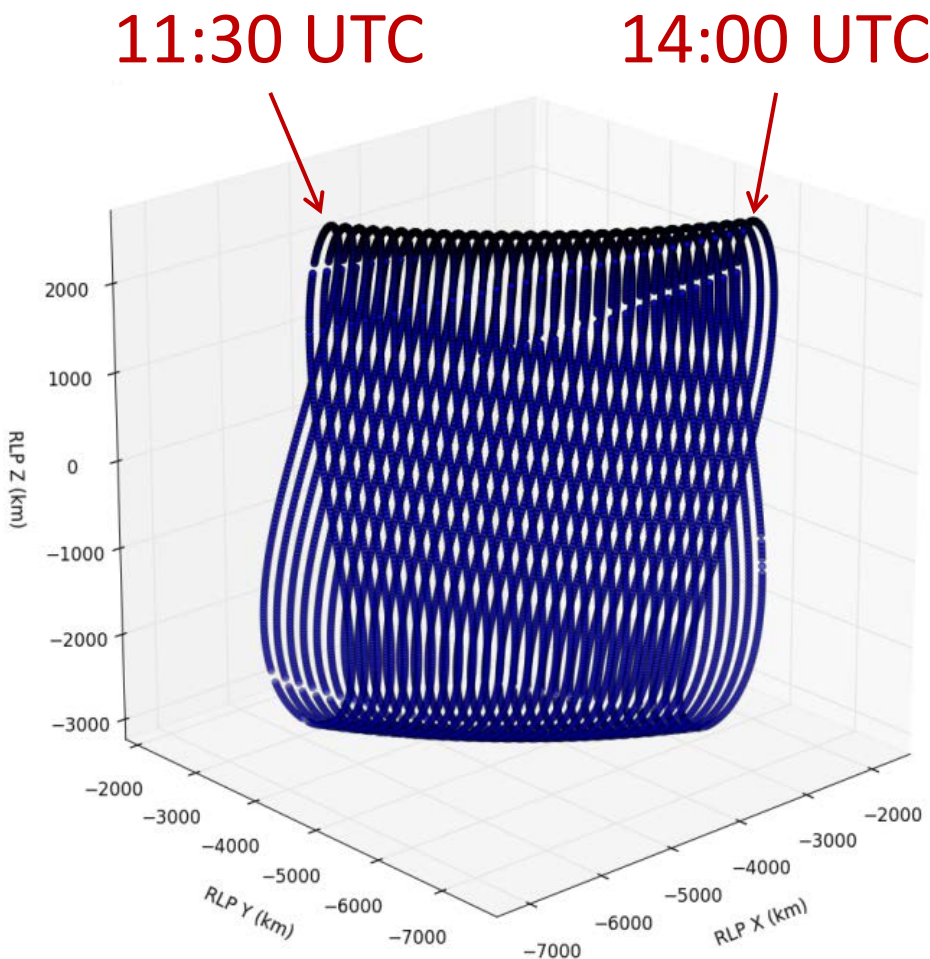
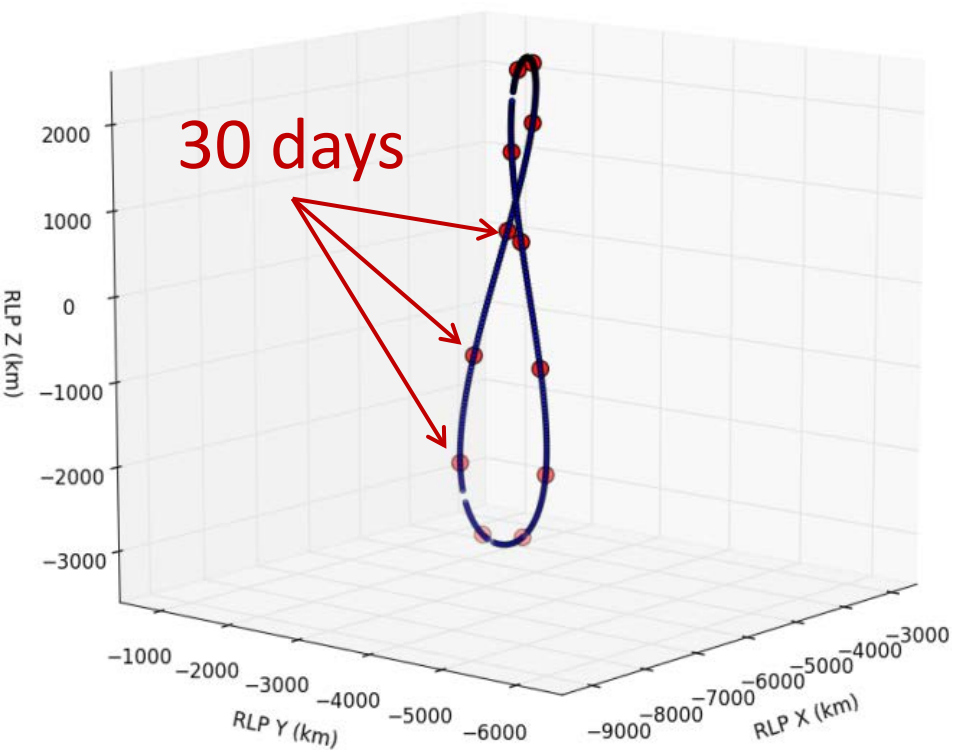
Agenda



- Introduction
- **Injection States**
- CR3BP Explanation
- Matching Orbits in the CR3BP
- Conclusion



Launch Separation States

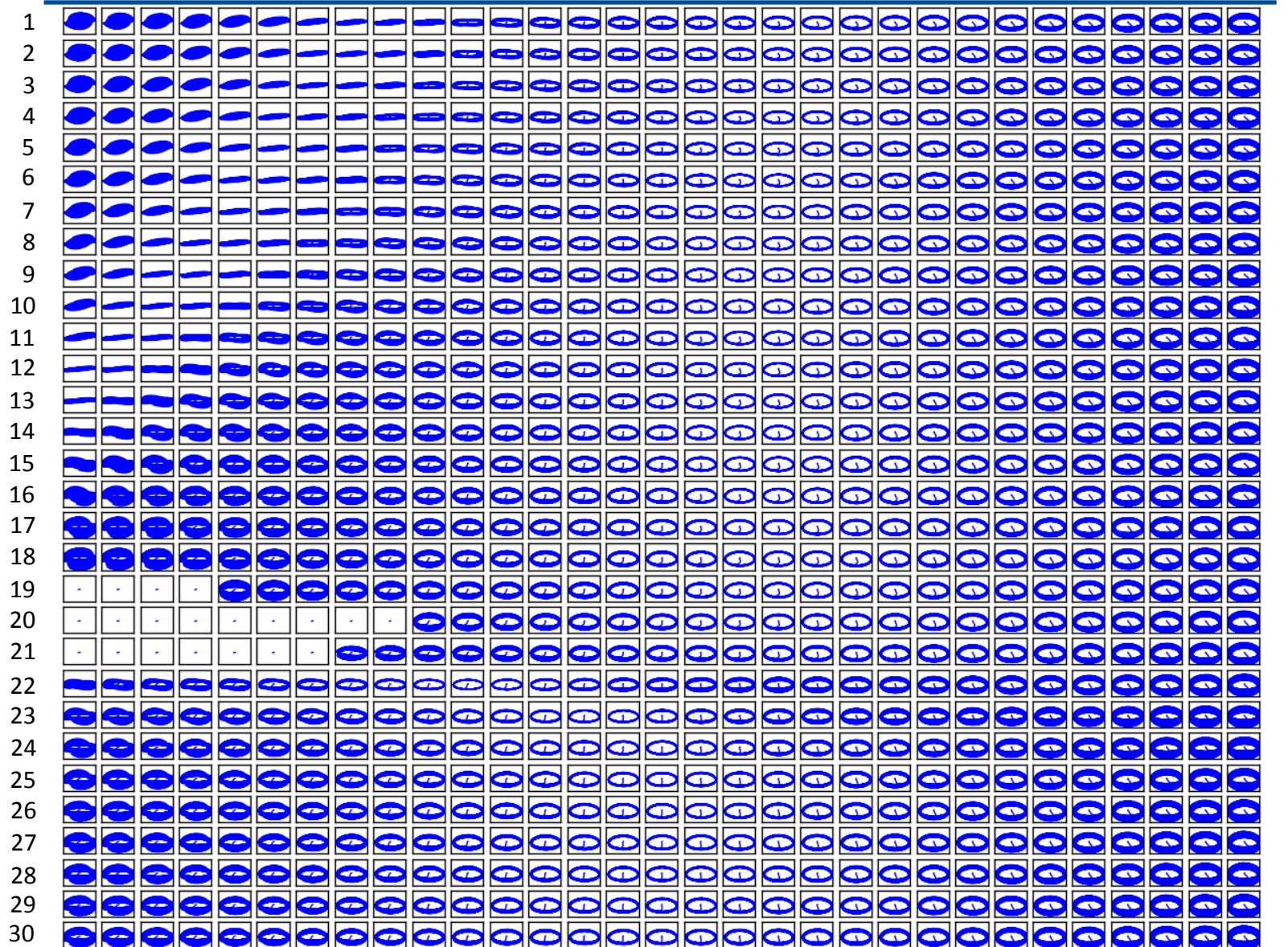


Separation state is constant in ECEF



Variation in Orbit Geometry

October 2018

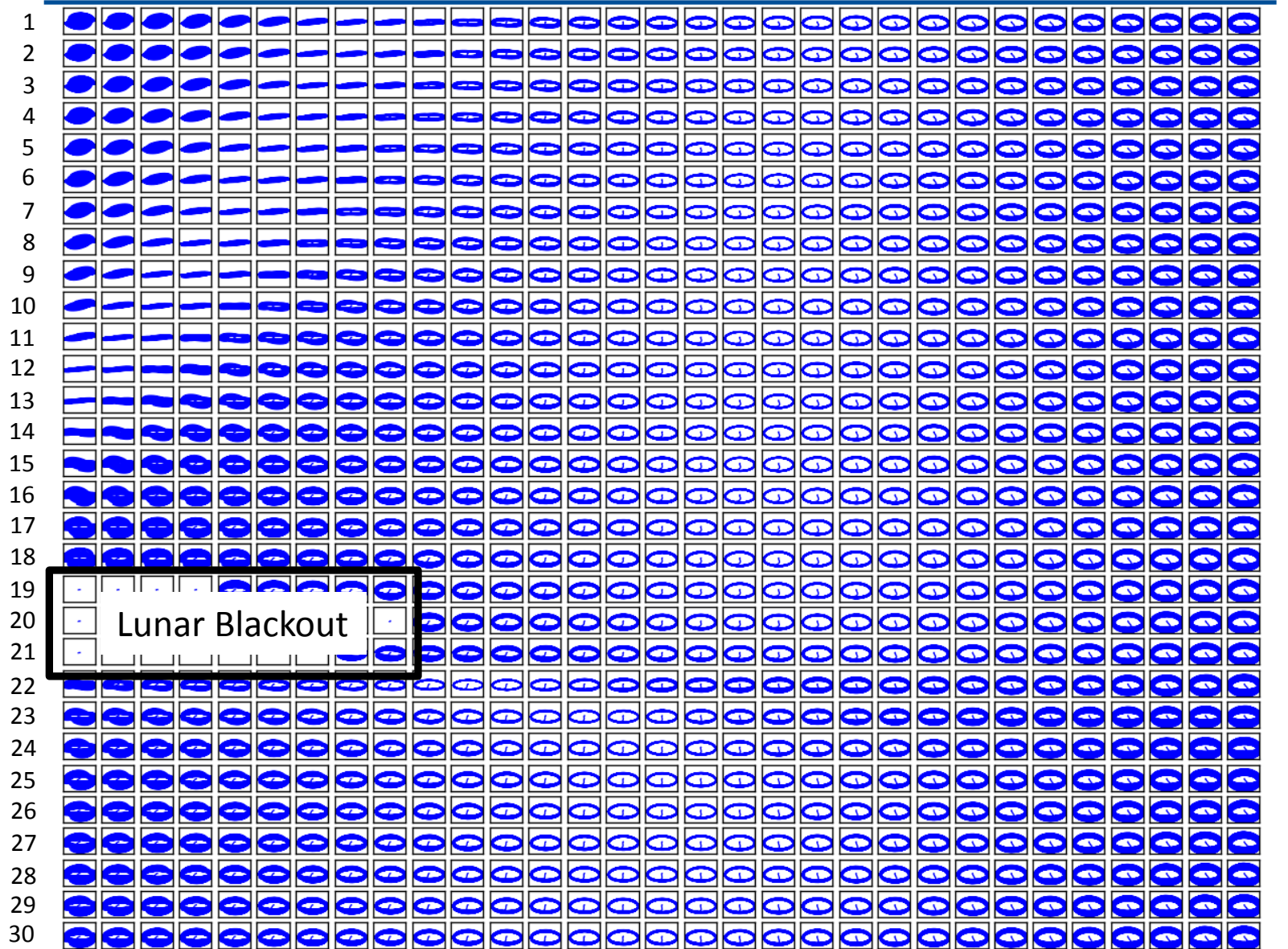


Launch Epoch (UTC)



Variation in Orbit Geometry

October 2018

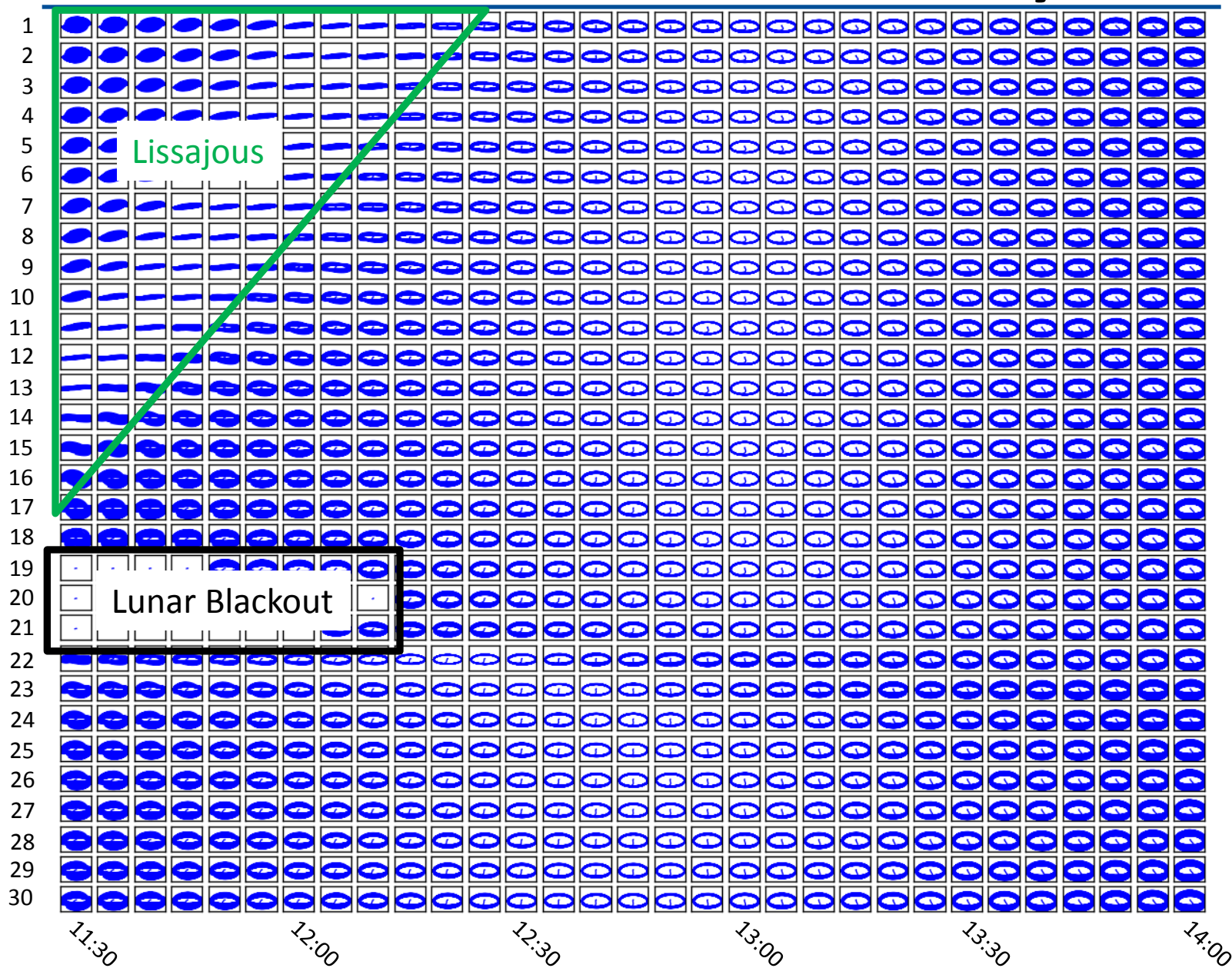


Launch Epoch (UTC)



Variation in Orbit Geometry

October 2018

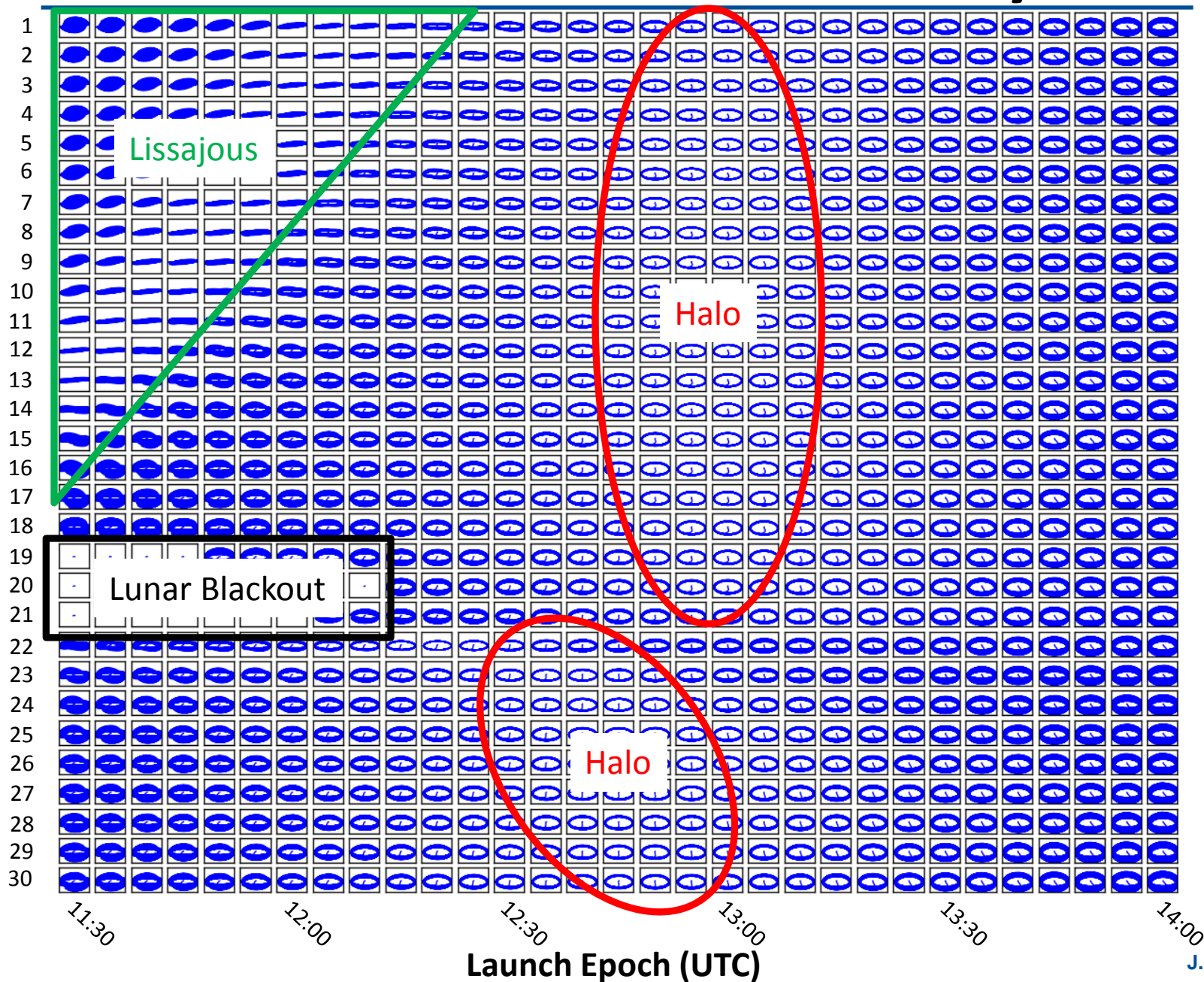


Launch Epoch (UTC)



Variation in Orbit Geometry

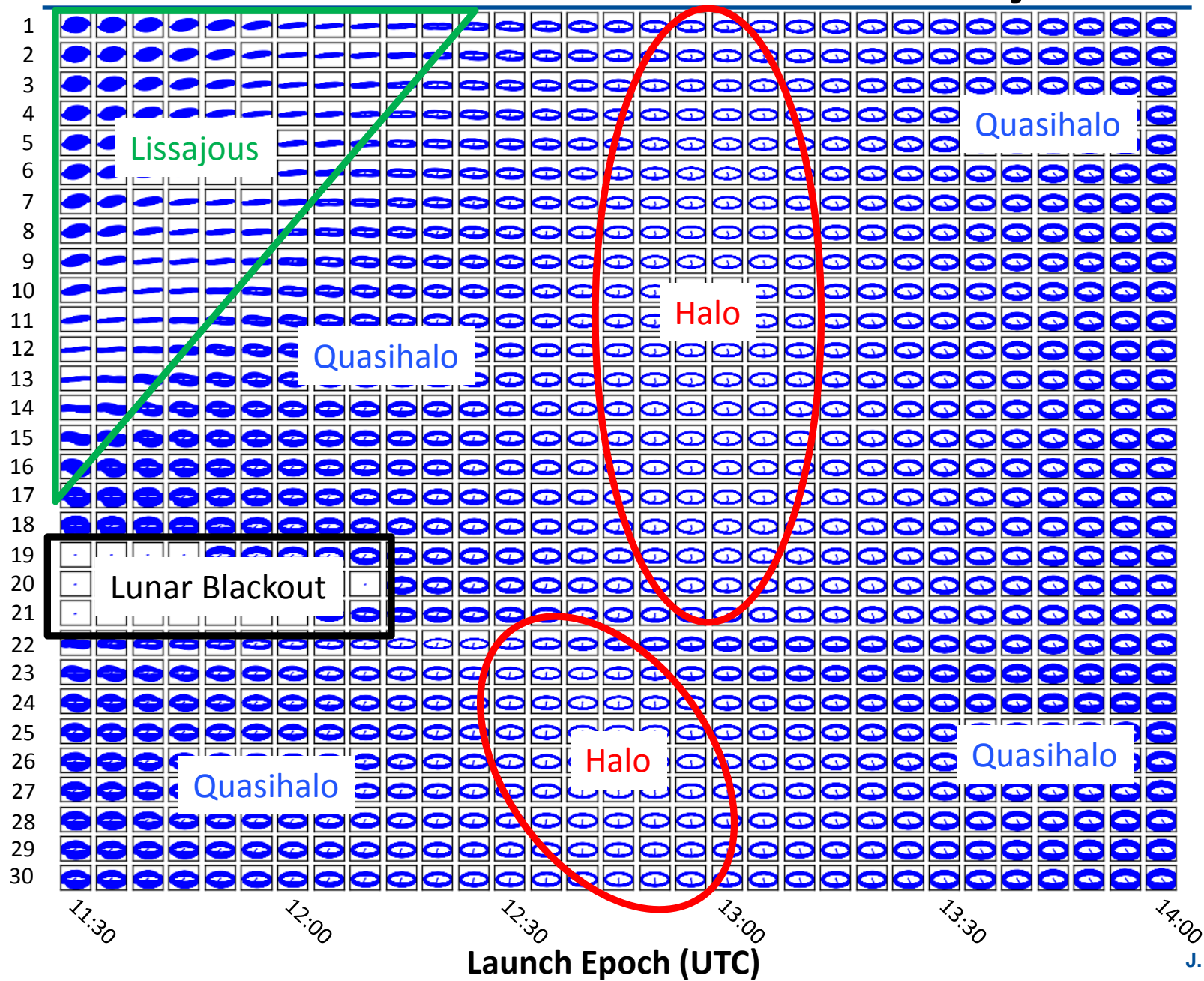
October 2018





Variation in Orbit Geometry

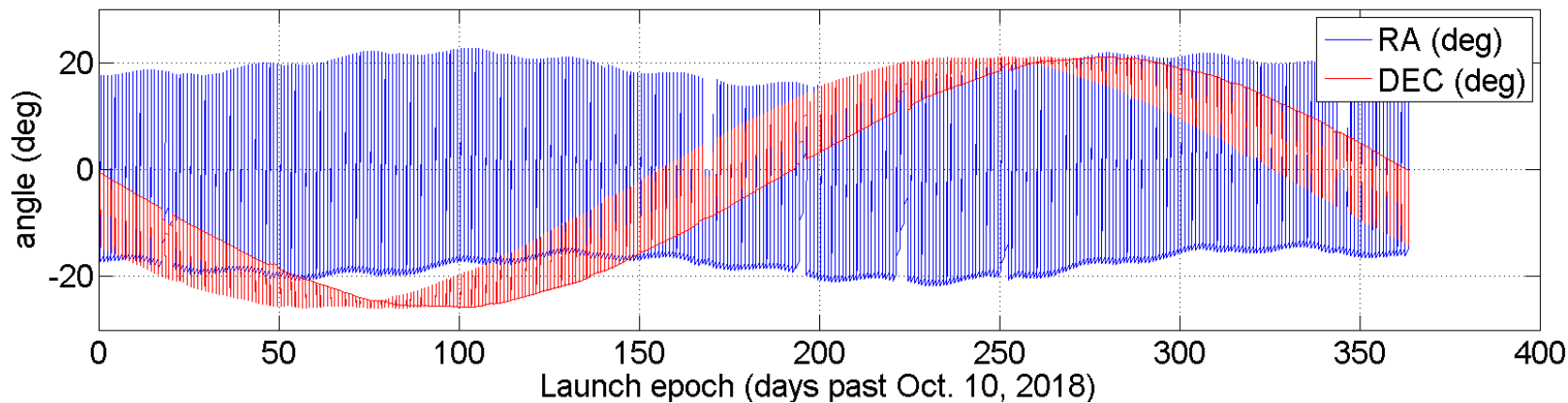
October 2018





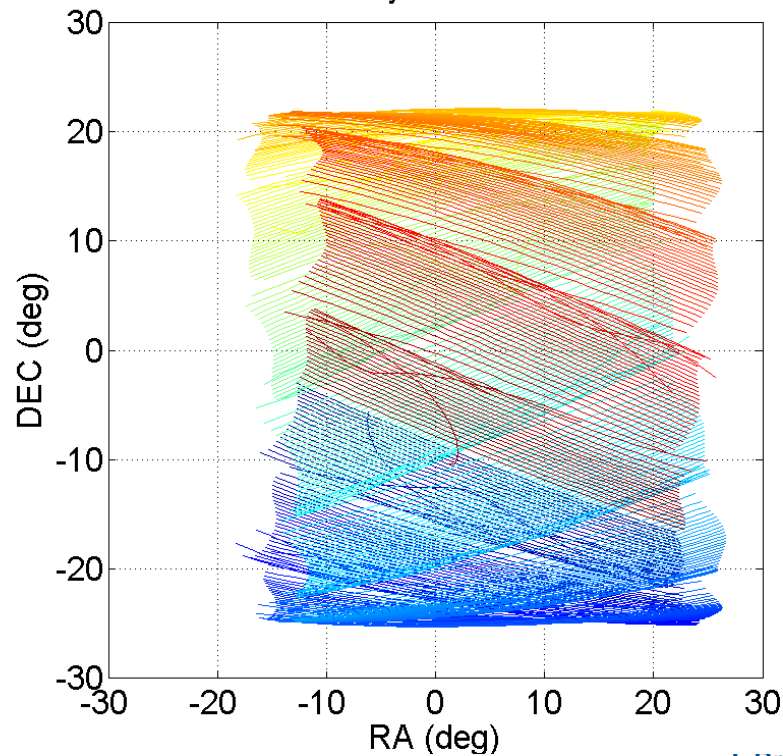
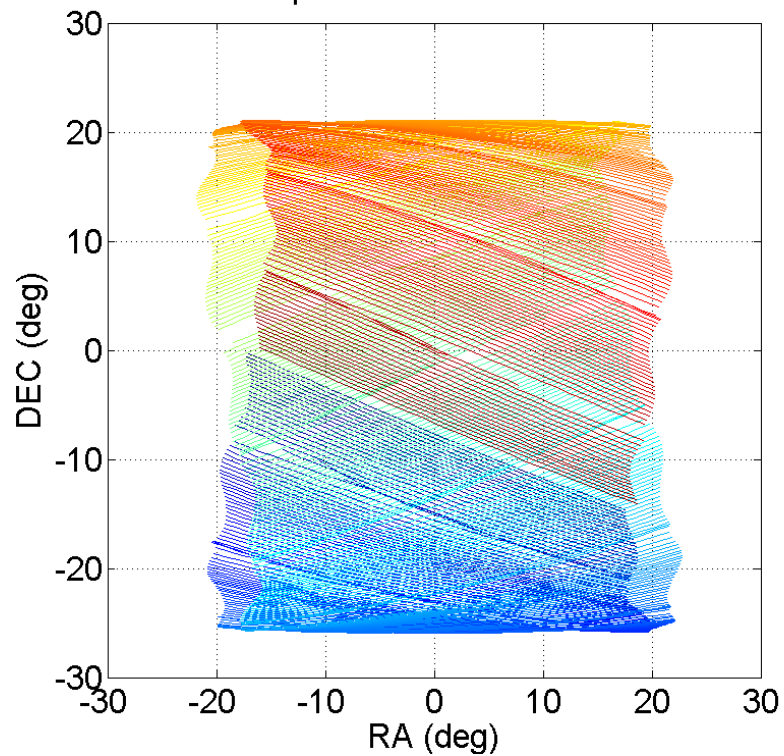
Post-MCC-1a State

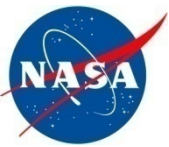
RLP position RA and DEC variation with time



RLP position RA-DEC curves

RLP velocity RA-DEC curves

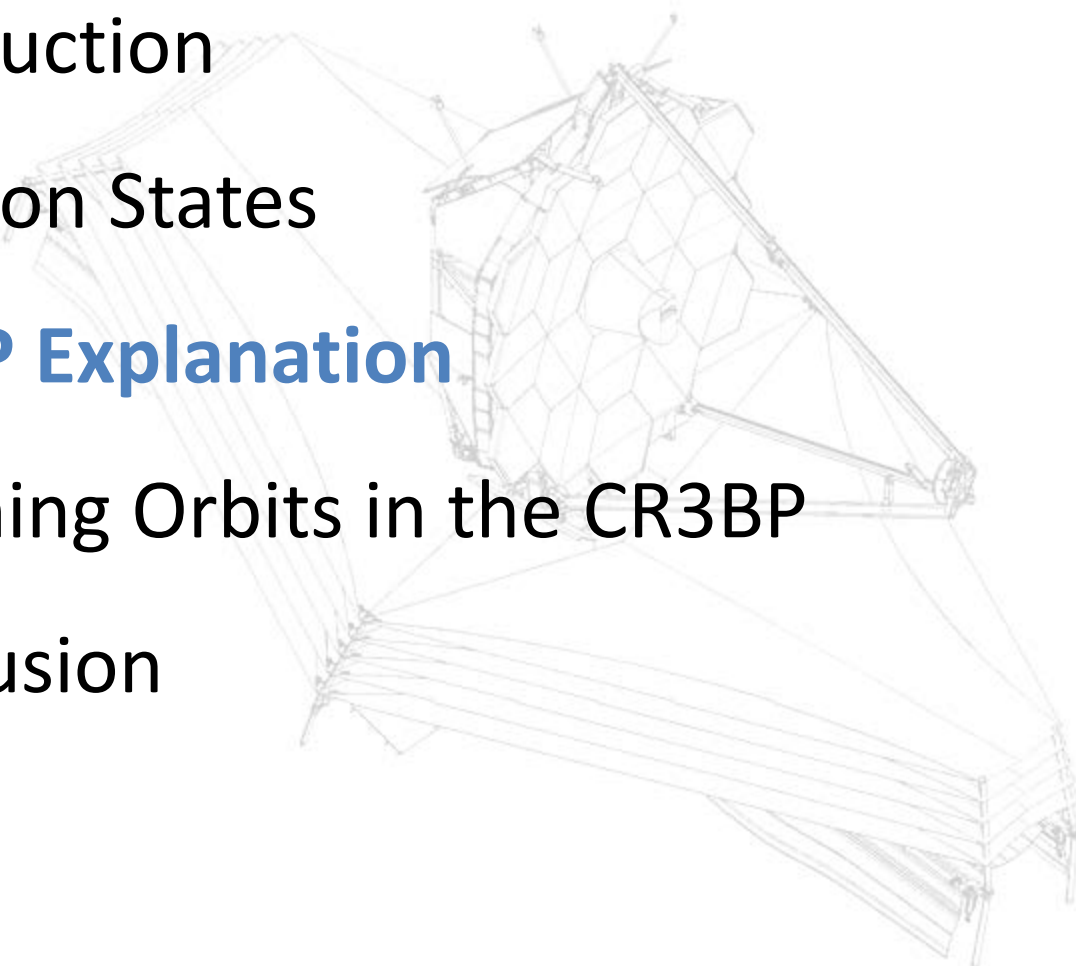




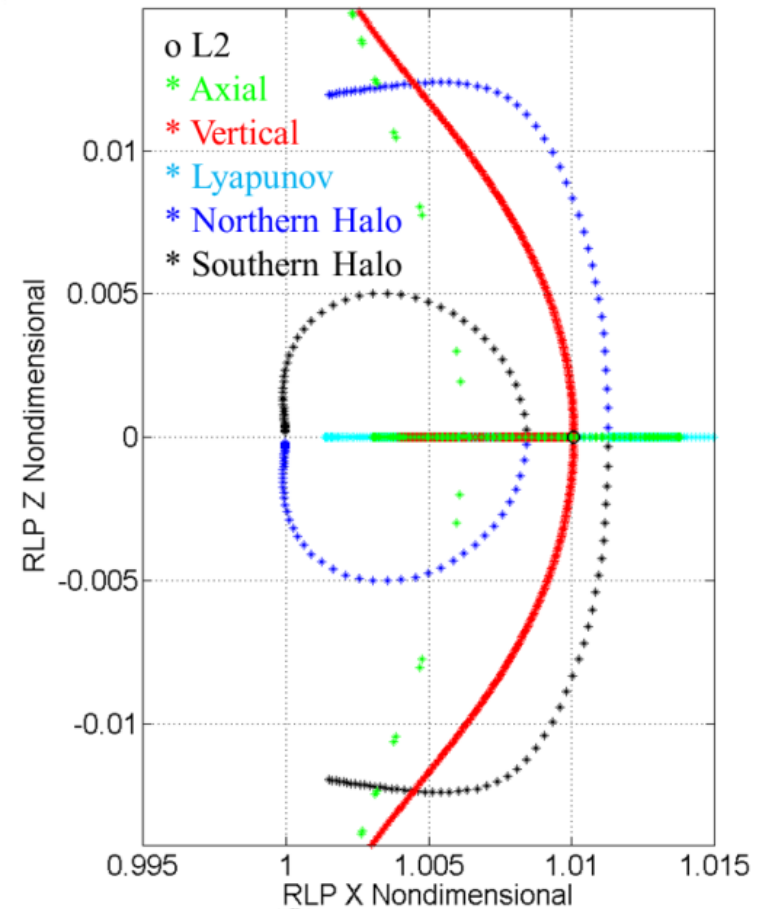
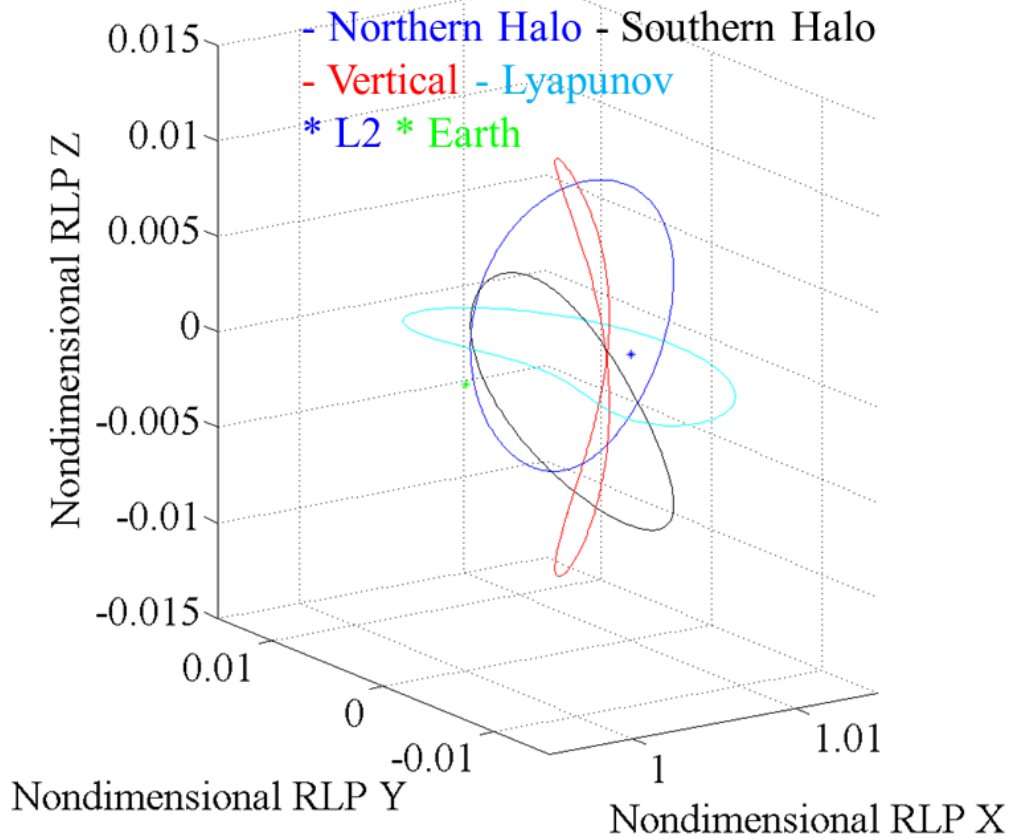
Agenda



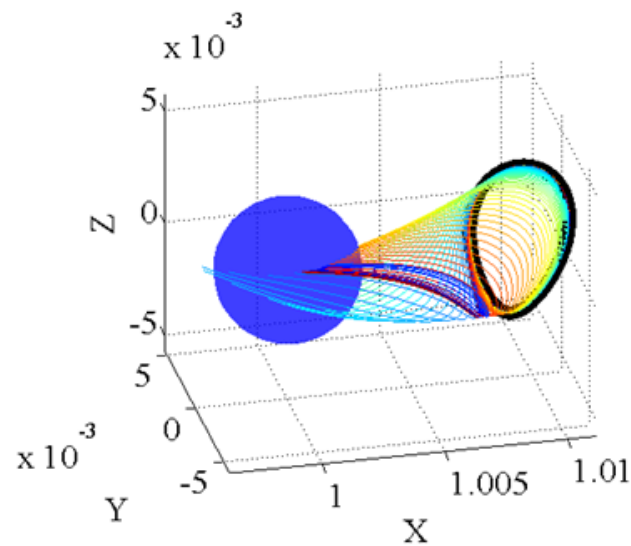
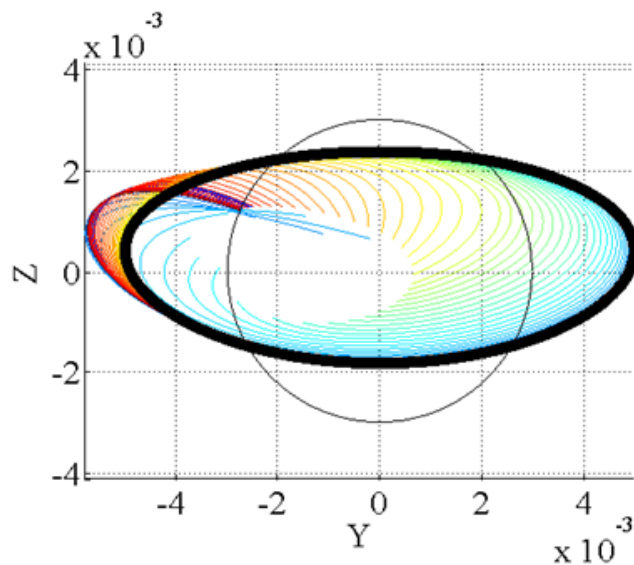
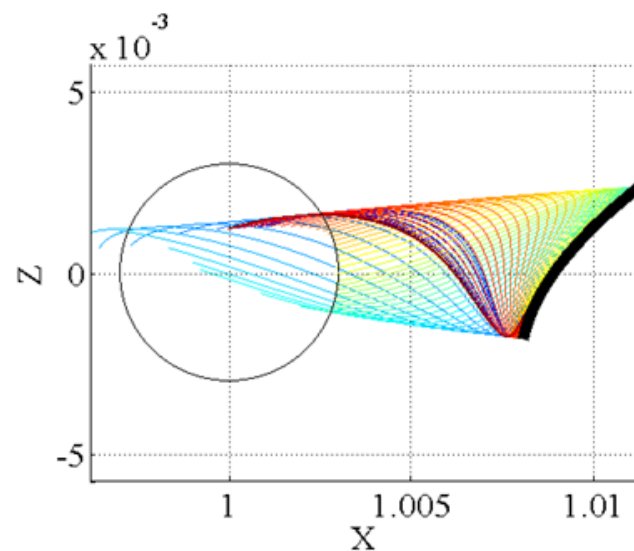
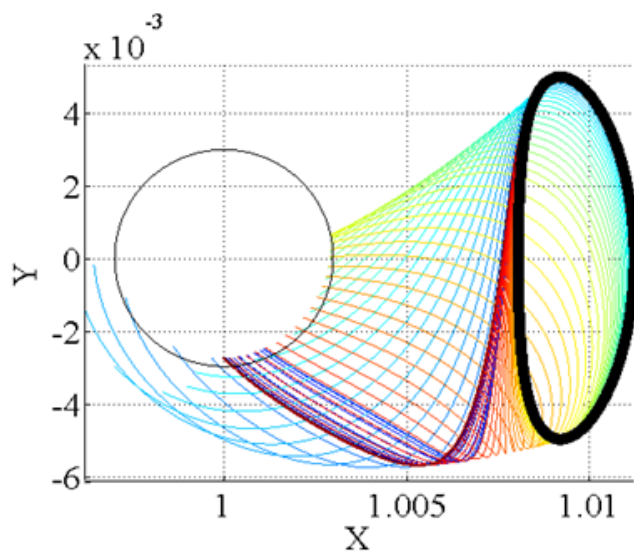
- Introduction
- Injection States
- **CR3BP Explanation**
- Matching Orbits in the CR3BP
- Conclusion



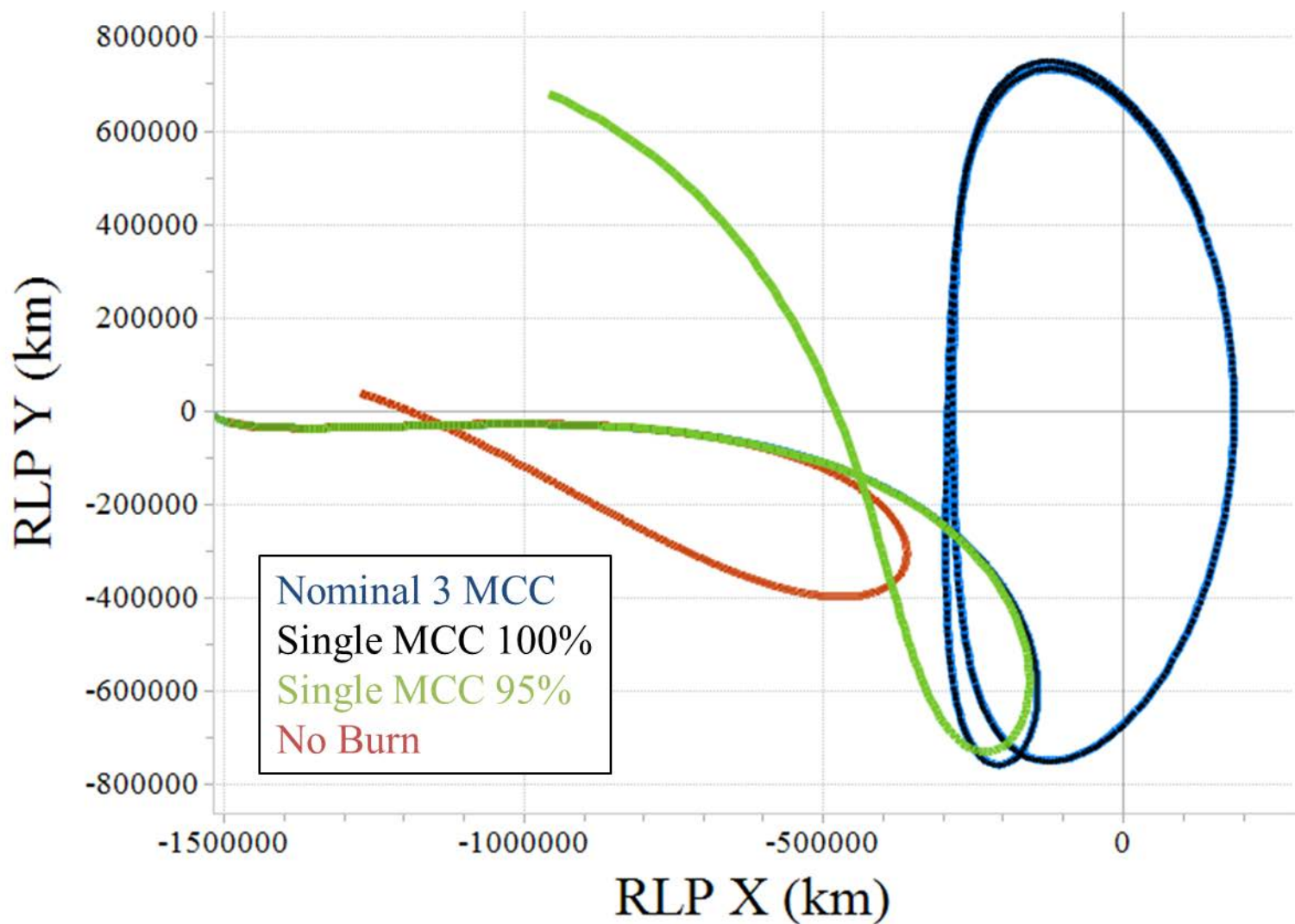
Sample Periodic Orbits in the CR3BP

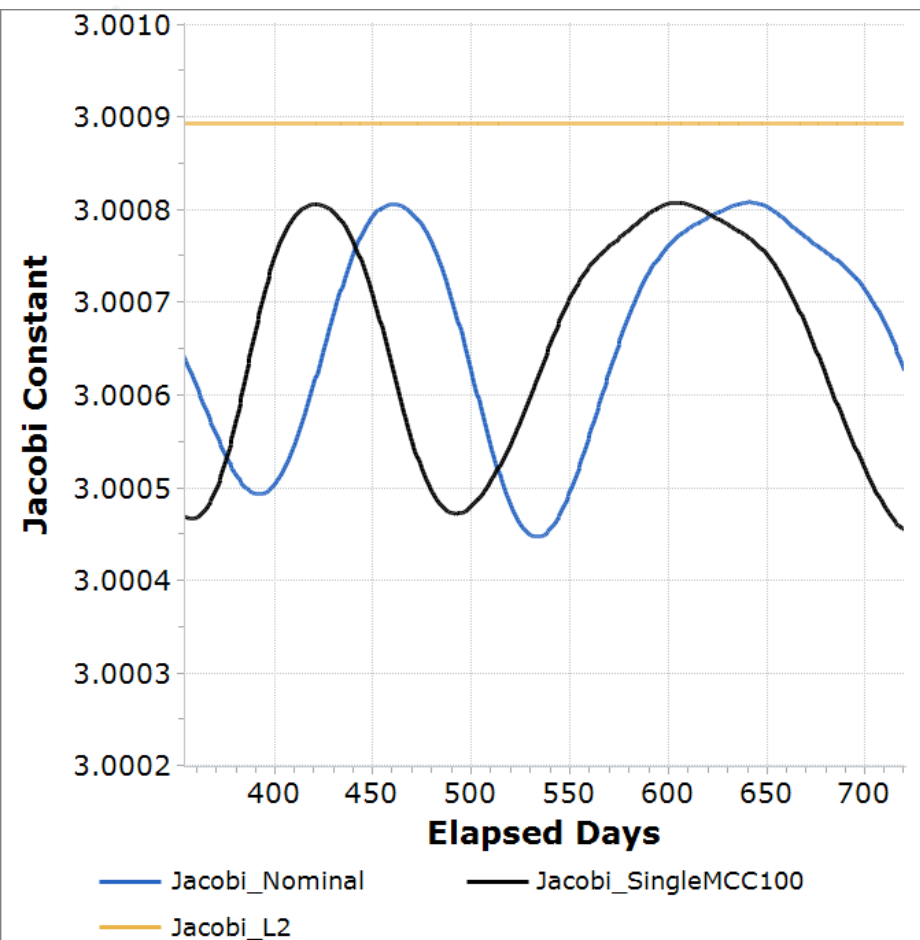
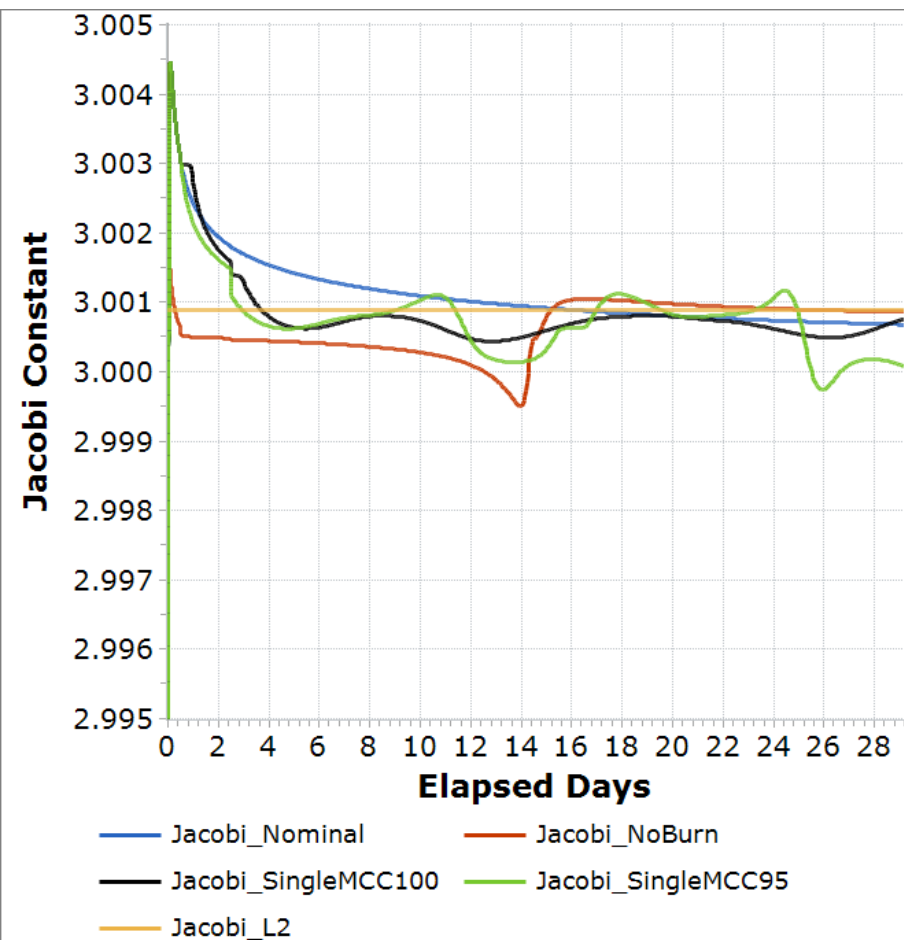


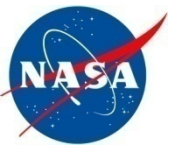
Stable Manifold



Near Ballistic Transfer



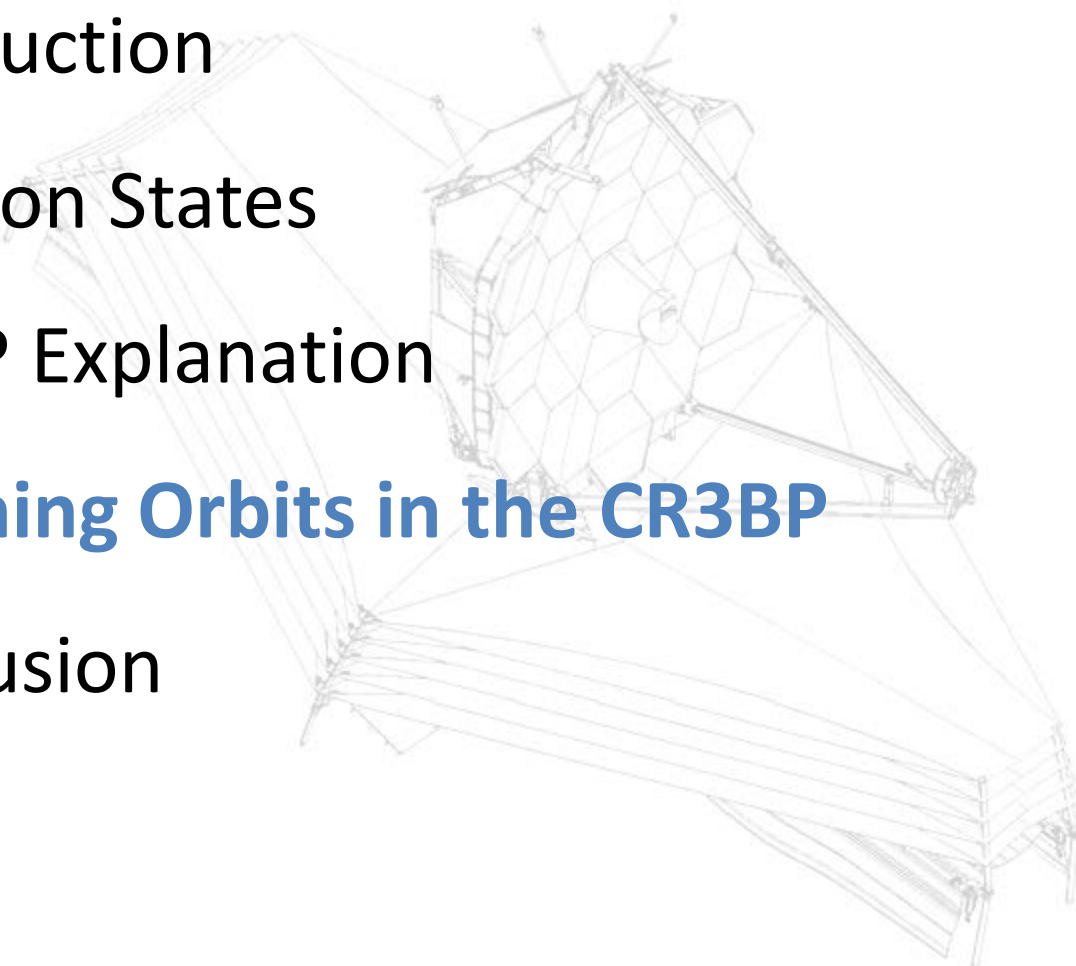




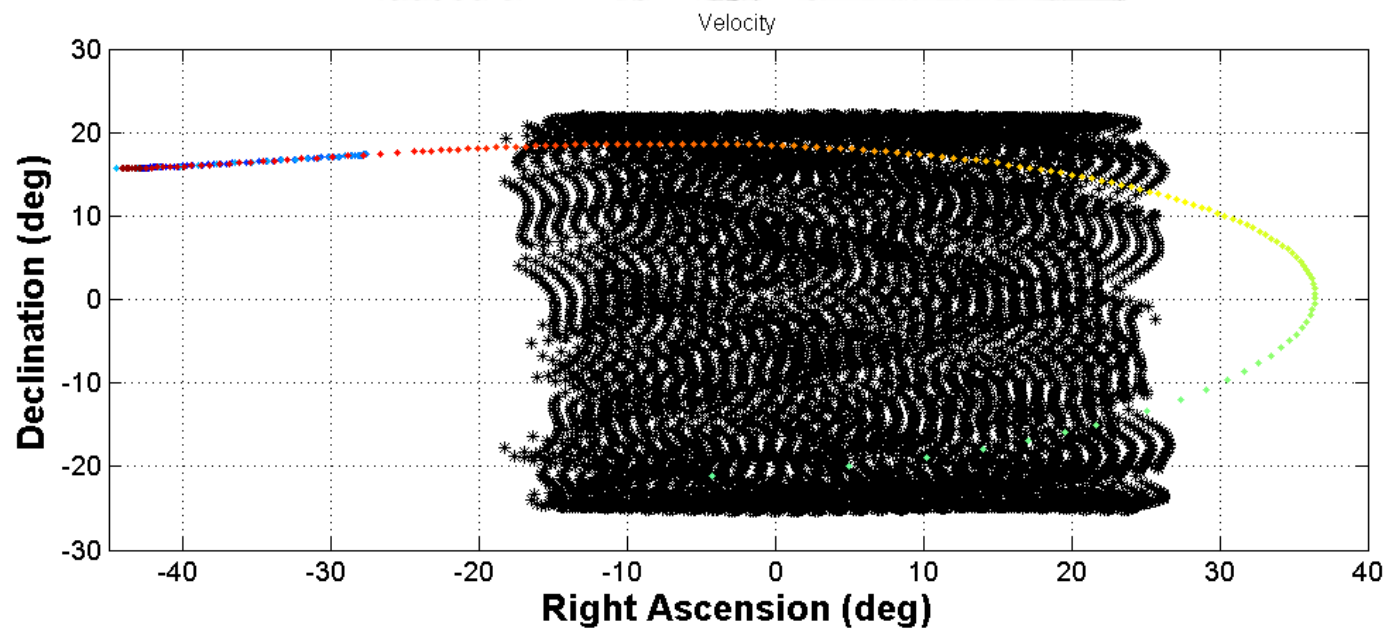
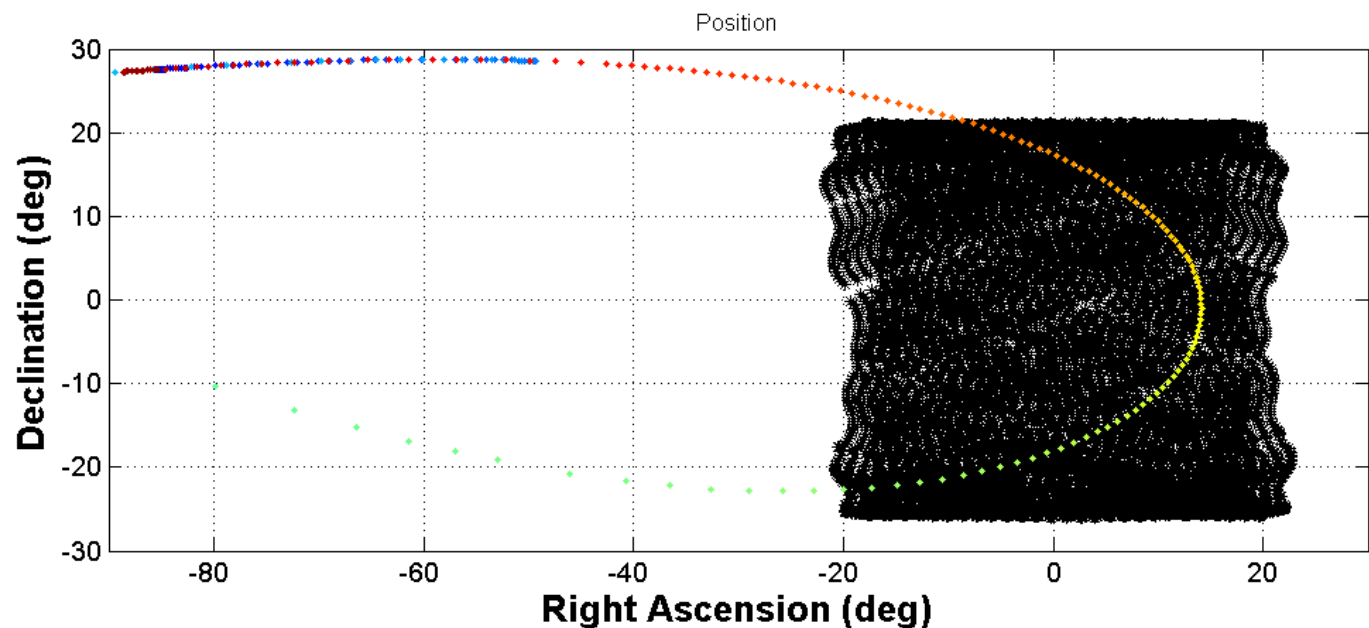
Agenda



- Introduction
- Injection States
- CR3BP Explanation
- **Matching Orbits in the CR3BP**
- Conclusion

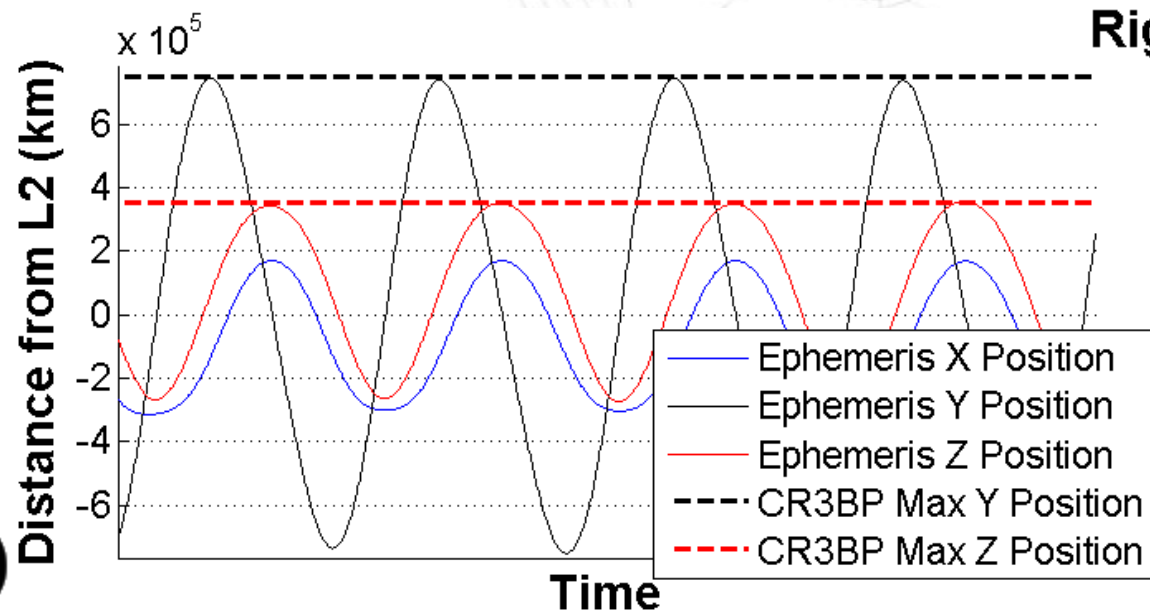
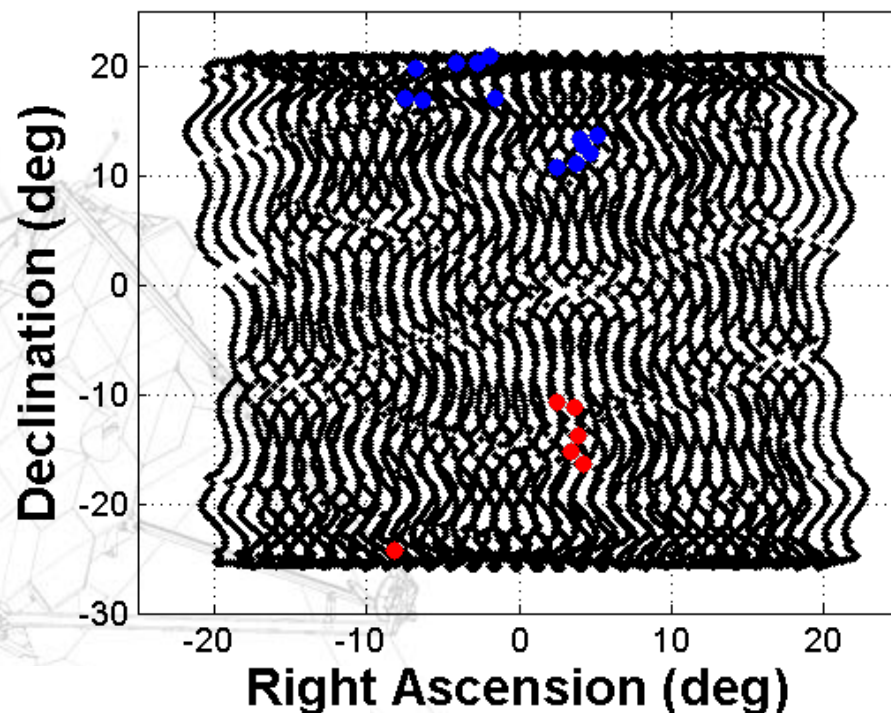


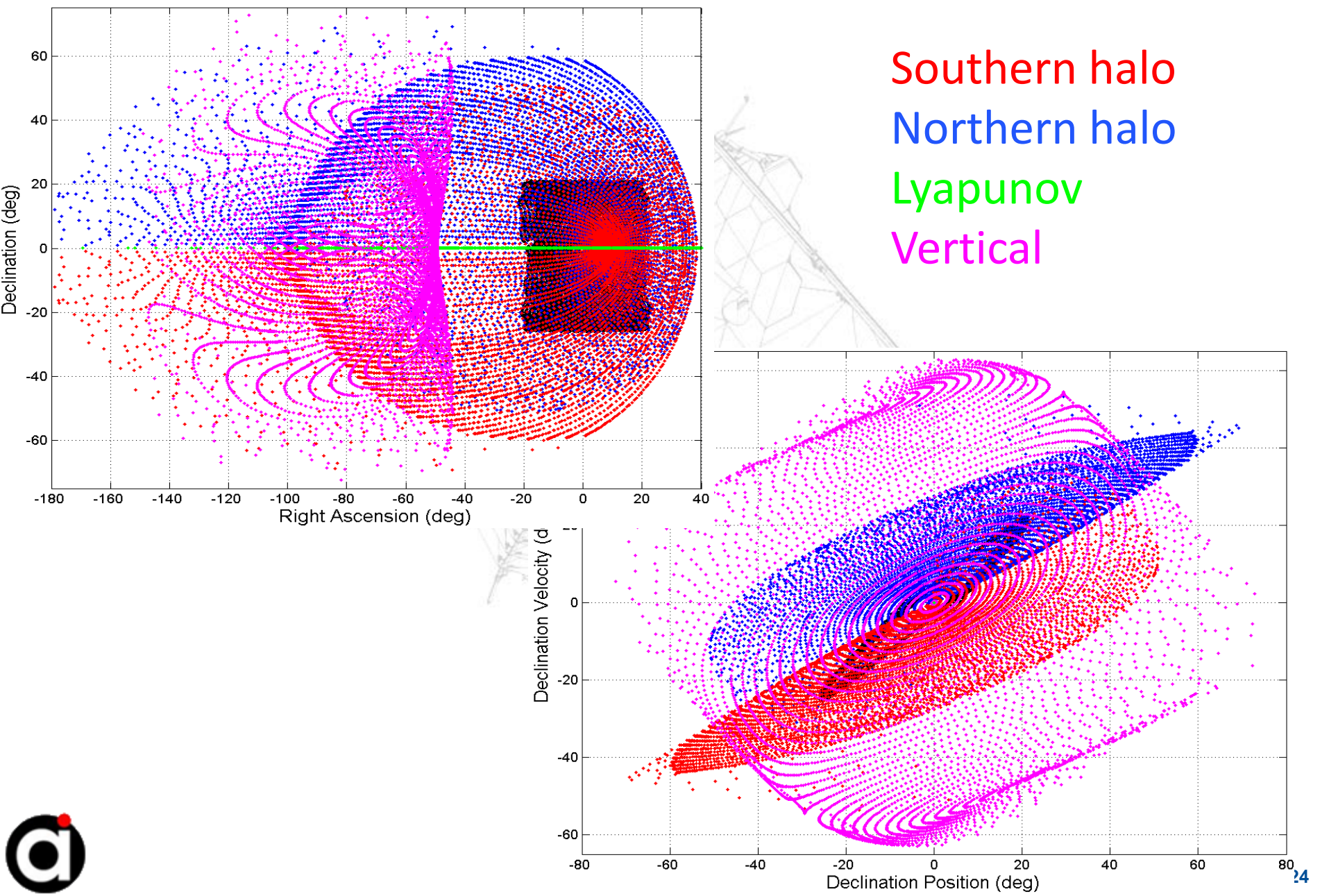
Manifold Intersection with Injection

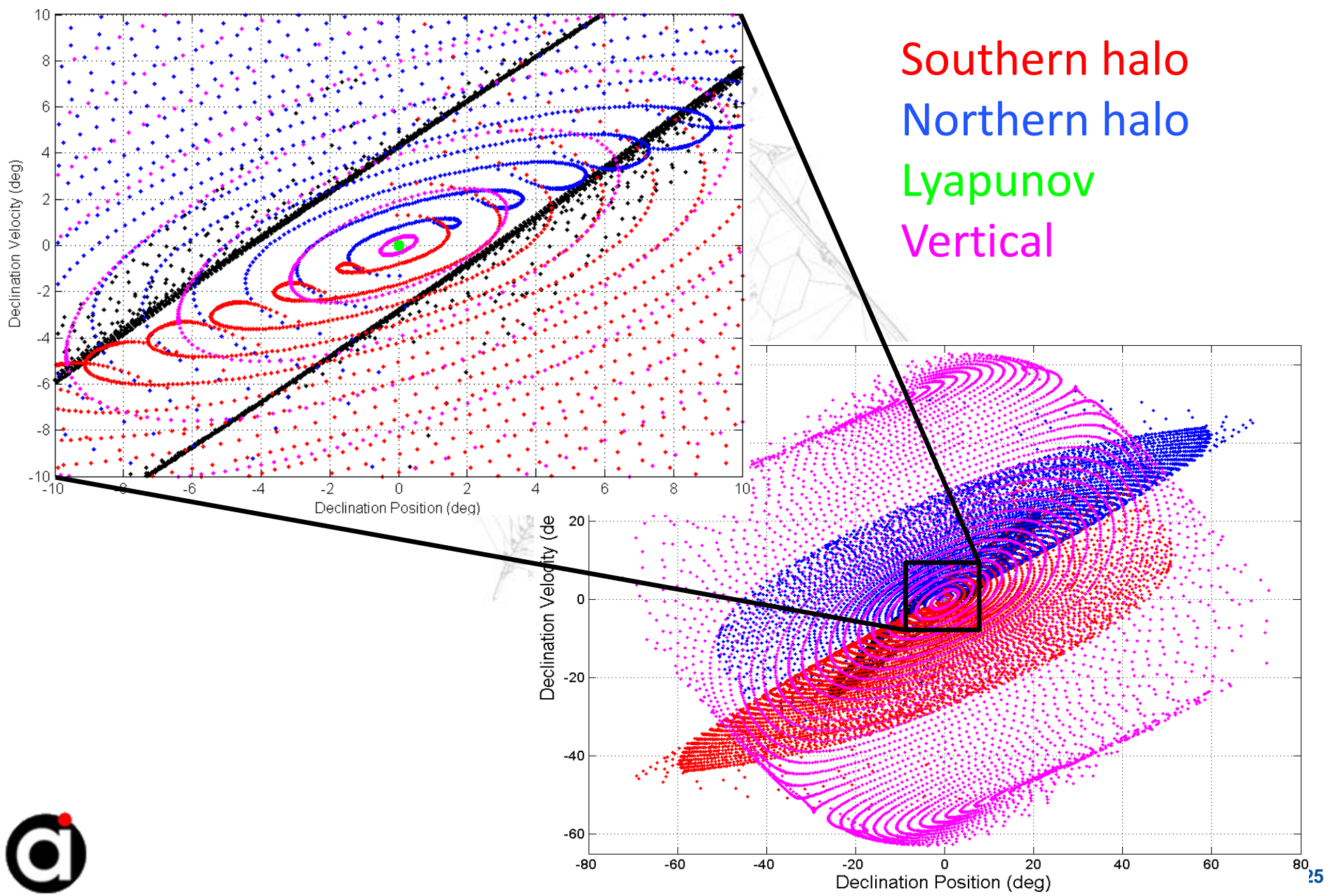


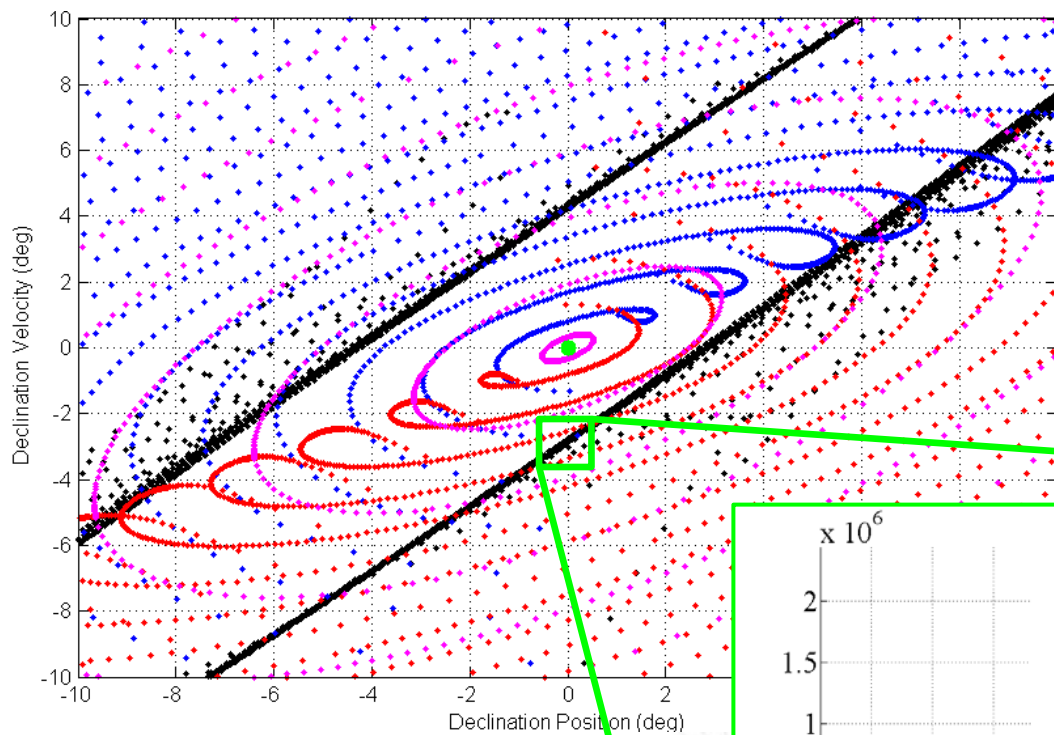
Matching States with Halo Manifolds

- Find injections states that intersect with halo manifolds in 4D
- Orbit amplitudes from CR3BP match trajectory in full ephemeris model



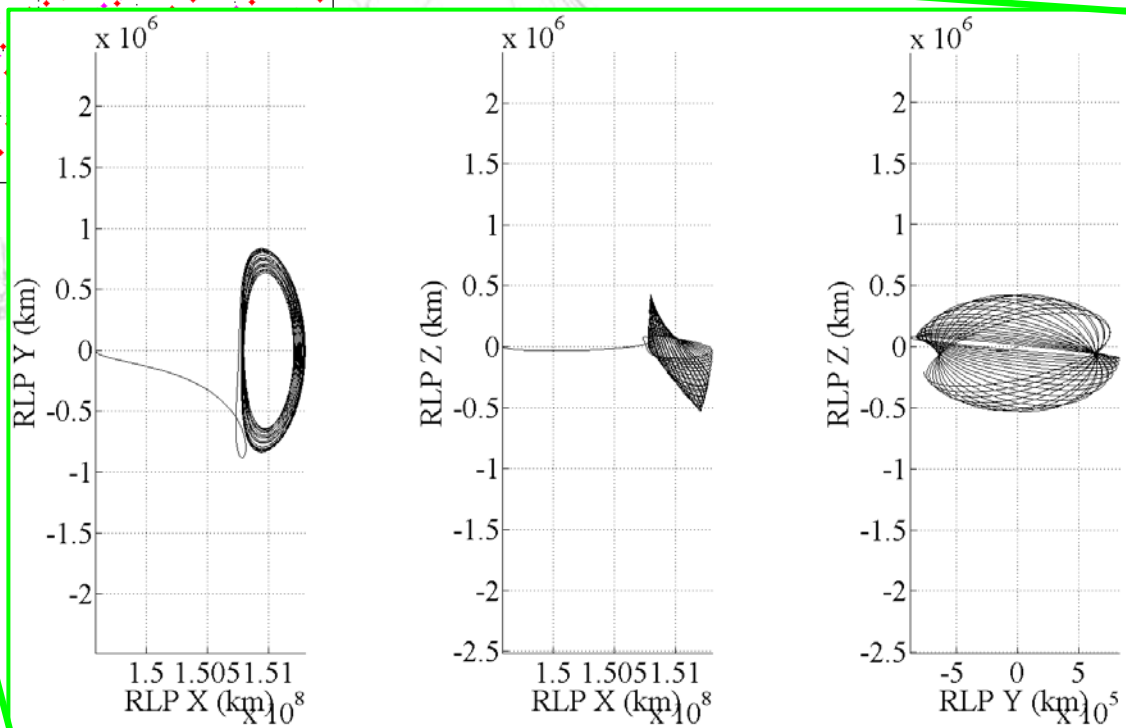


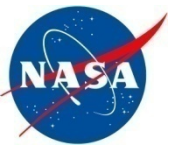




Southern halo
Northern halo
Lyapunov
Vertical

Injection states closest to Lyapunov result in Lissajous

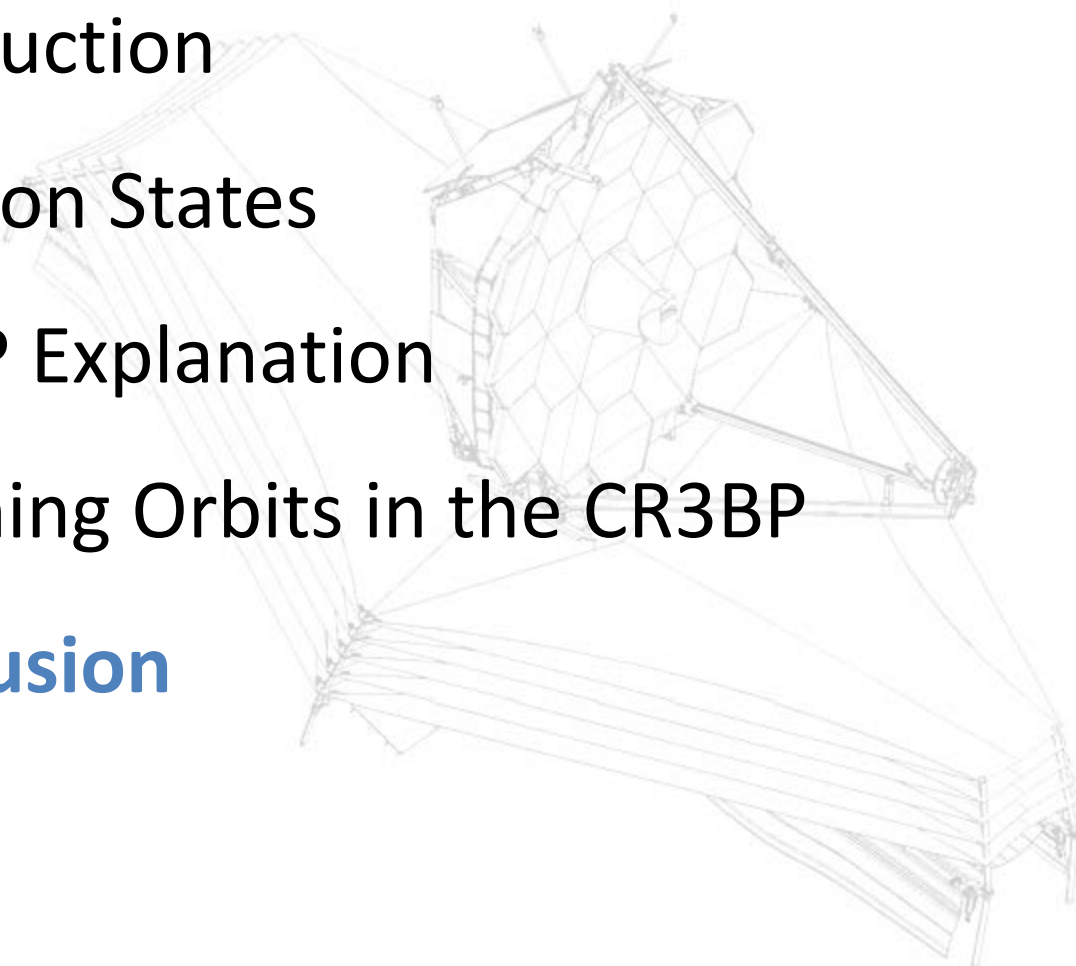




Agenda

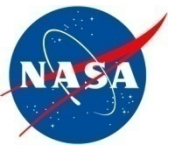


- Introduction
- Injection States
- CR3BP Explanation
- Matching Orbits in the CR3BP
- **Conclusion**



Conclusion

- LV separation state is fixed ECEF, so inertial states vary with hourly, daily, monthly, and yearly frequencies
- The net effect of all frequencies leads to significant variations in orbit geometry
- Injection states can be matched with invariant manifolds of periodic orbits in the CR3BP to explain observed final orbit



Thank You

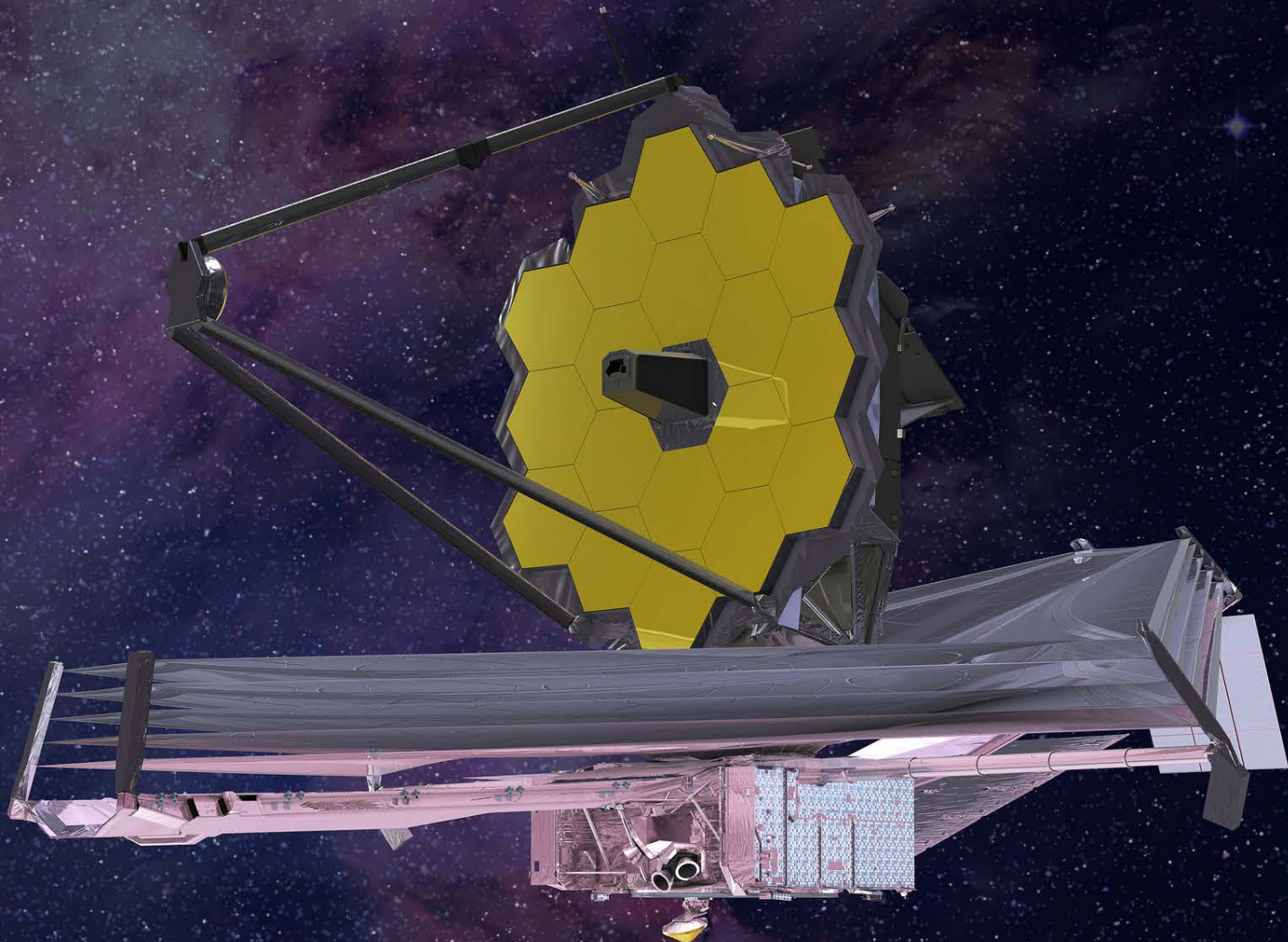


Image credit: http://jwst.nasa.gov/images_jwst.html

